



AEROSPACE RECOMMENDED PRACTICE

ARP5151™

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Superseding ARP5151

(R) Safety Assessment of General Aviation Airplanes and Rotorcraft in Commercial Service

RATIONALE

ARP5151 is updated commensurate with changes in ARP5150A and to reflect current industry practices.

INTRODUCTION

Safety is not self-sustaining. When an aircraft is delivered and is in its original type certificated condition, it has an initial level of safety. As it is operated, the level of safety is maintained through a continuing process of monitoring service experience, identifying safety related issues and opportunities, and then addressing these issues or opportunities through appropriate product or procedure changes. This continuing process may be referred to as the “ongoing safety assessment process.”

This document provides a systematic process for assessing ongoing safety of general aviation airplanes and rotorcraft (GAR). This process is intended to assist in focusing available resources in areas that maximize the potential to improve commercial aviation safety. Ongoing safety assessment relies on a cooperative effort among individual commercial operators, manufacturers, suppliers, airworthiness authorities, and other aviation service providers. There are variations in current practices throughout the industry. This document provides guidelines intended to enhance consistency of approach in how aircraft safety assessments are conducted and how GAR aircraft are operated in commercial service worldwide. This document is not a regulation. It is, rather, a reference summary of best practices where a reader can go to obtain more detailed information. The user is not constrained to use any of the elements contained within this document. This document allows a user to seek improvements by comparing existing methods with those listed herein.

To improve safety during the complete aircraft life cycle, it is not sufficient to assess the safety of the aircraft only during its design phase. Ongoing aircraft operations should be evaluated for safety (e.g., maintenance or operation procedures). The aircraft is evolving and changing during the “in-service” phase (e.g., product improvements, modifications). For these reasons, safety should be assessed during the “in-service” phase of the aircraft life cycle. In order to do that, information can be collected, monitored, and analyzed. In addition to maintaining the safety of the aircraft, there is also a desire to enhance safety. The GAR aircraft accident rate has been steadily declining. Use of information within this document is intended to continue this industry improvement.

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1. SCOPE

This document describes a process that may be used to perform the ongoing safety assessment for (1) GAR aircraft and components (hereafter, aircraft), and (2) commercial operators of GAR aircraft. The process described herein is intended to support an overall safety management program. It is to help a company establish and meet its own internal standards. The process described herein identifies a systematic means, but not the only means, to assess continuing airworthiness.

Ongoing safety management is an activity dedicated to assuring that risk is identified and properly eliminated or controlled. The safety management process includes both safety assessment and economic decision-making. While economic decision-making (factors related to scheduling, parts, and cost) is an integral part of the safety management process, this document addresses only the ongoing safety assessment process. This ongoing safety assessment process includes safety problem identification and corrective action, tracking of problems, the application of "lessons learned" to improve the efficiency of the process, and reduction of the time to achieve corrective action in the field.

ARP5150 is the recommended practice for the safety assessment of Transport Airplanes in Commercial Service. ARP5151 is the recommended practice for the safety assessment process for GAR aircraft in commercial services. While the processes are similar, their implementations are different due to operations, data availability, and sizes of individual operations.

1.1 How to Use This Document

Each organization reviewing this document needs to establish which sections may prove helpful in improving or supplementing their existing safety related practices. The specific applicability and usefulness of the individual guidelines, methods, and tools will vary from organization to organization. Due to the wide variability in GAR manufacturers, aircraft maintainers/modifiers, vendors, users, and operators, this document provides a generic safety assessment process that may be tailored to fit a company's specific situation.

1.2 Intended Users

The intended users of this document include, but are not limited to, GAR commercial operators, airframe/engine manufacturers, component manufacturers, equipment suppliers, maintenance/modification/repair centers, and airworthiness authorities. Any organization involved with the safety assessment and safety management of GAR aircraft or its components may be a potential user. Three specific levels of users have been defined. Those users have differing potential actions and types of information available thus their responses will vary. The three levels of users are:

Level A - Original Equipment Manufacturer (OEM) of the airframe, engine, or propeller. These organizations and others that hold a type certificate or production authorization have responsibility for their initial design and their changes to that design. These organizations also have a responsibility under 14 CFR 21.3 to report failures, malfunctions, and defects to the airworthiness authorities with the guidance of AC21-9B. Level A includes those organizations that did not produce the aircraft components (such as military surplus aircraft), but have a type certificate issued to them. Level A organizations have the responsibility for dissemination of corrective action, and may have worldwide service information on their products. This safety assessment process may be applied to Level A organizations' products used in non-commercial service.

Level B - Component manufacturers, supplemental type certificate (STC), and part manufacturing approval (PMA) holders and technical standard order (TSO) holders of aircraft, engines, or equipment. These organizations have a responsibility under 14 CFR 21.3 to report failures, malfunctions, and defects to the airworthiness authorities with the guidance of AC21-9B. Repair stations have a responsibility under 14 CFR 145.221 to report failures, malfunctions, and defects to the airworthiness authorities. Level B organizations usually have database information that is limited to their own products or components, but are still responsible for identification of service issues and corrective action for their equipment. This safety assessment process may be applied to Level B organizations' products/services used in non-commercial services.

Level C - Commercial GAR operators. These operators receive compensation for their aircraft services and have information limited to their internal operations. Level C organizations have internal corrective action responsibilities. Reporting of service and operational issues are usually initiated at the operator level. These organizations also have a responsibility under 14 CFR 135.415 to report to the airworthiness authorities, all failures, malfunctions, and defects related to their 14 CFR 135 operations. While it is recognized that some operations (e.g., use of an aircraft incidental to another type of operation) involve business or other types of use (e.g., 14 CFR 91 or equivalent), this safety assessment process is intended to apply to those aircraft, components, and operations used for compensation or hire which fall under 14 CFR 135.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

ARP4754	Guideliens for Development of Civil Aircraft and Systems
ARP4761	Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment
ARP5150	Safety Assessment of Transport Airplanes in Commercial Service

2.2 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Technical Report.

2.2.1 Code of Federal Regulations (CFR)

Available from the United States Government Printing Office, 732 North Capitol Street, NW, Washington, DC 20401, Tel: 202-512-1800, www.gpo.gov.

14 CFR 21	Certification Procedures for Products and Parts
14 CFR 23	Airworthiness Standards: Normal Category Airplanes
14 CFR 25	Airworthiness Standards: Transport Category Airplanes
14 CFR 27	Airworthiness Standards: Normal Category Rotorcraft
14 CFR 29	Airworthiness Standards: Transport Category Rotorcraft
14 CFR 33	Airworthiness Standards: Aircraft Engines
14 CFR 35	Airworthiness Standards: Propellers
14 CFR 91	General Operating and Flight Rules
14 CFR 135	Air Taxi Operators and Commercial Operators
14 CFR 145	Repair Stations

2.2.2 FAA Publications

Available from Federal Aviation Administration, 800 Independence Avenue, SW, Washington, DC 20591, Tel: 866-835-5322, www.faa.gov.

AC 21-9 Manufacturers Reporting Failures, Malfunctions, or Defects

AC 39-8 Continued Airworthiness Assessments of Powerplant and Auxiliary Power Unit Installations of Transport Category Airplanes

FAA Order 8040.4B Safety Risk Management Policy

2.2.3 Other Publications

System Safety Analysis Handbook (System Safety Society)

2.3 Definitions

CONTINUING AIRWORTHINESS: Actions to maintain an aircraft/component in a type certificated condition.

COMMERCIAL SERVICE: Carriage by aircraft in air commerce of persons or property for compensation or hire, such as under 14 CFR 135.

EVENT: An occurrence which could potential affect safe operation of aircraft.

GENERAL AVIATION AIRPLANES: Fixed-wing aircraft certificated under 14 CFR 23.

HAZARD: The potential for an undesired and unexpected event resulting in damage or injury or environmental harm.

IN-SERVICE PHASE: The portion of an aircraft/component life beginning at its introduction to the fleet and ending with its retirement from service.

ISSUE: A potentially hazardous situation which requires monitoring.

LESSONS LEARNED: Application of past experience to current tasks.

NON-COMMERCIAL SERVICE: Operations of aircraft not involved in commercial service such as 14 CFR 91, 133, and 141, etc.

ONGOING SAFETY ASSESSMENT: The continuing risk management process involving monitoring of the field experience, problem identification, and resolution.

ROTORCRAFT: Rotary-wing aircraft certificated under 14 CFR 27 or 29.

2.4 Abbreviations

AC Advisory Circular (FAA)

ARP SAE Aerospace Recommended Practice

CFR United States of America Code of Federal Regulations

GAR General Aviation Airplanes and Rotorcraft

NTSB National Transportation Safety Board

OEM Original Equipment Manufacturer

PMA	Part Manufacturing Approval (FAA)
SDR	FAA Service Difficulty Report
SMS	Safety Management System
STC	FAA Supplemental Type Certificate
TC	FAA Type Certificate
TSO	FAA Technical Standard Order

3. ONGOING SAFETY ASSESSMENT

Ongoing safety assessment continues the effort started during the aircraft/component design phases, begins with the new aircraft/component introduction into service, and continues until the aircraft/component is retired from service. The safety of the aircraft depends on numerous factors, which may include the original design, manufacturing, flight crew and maintenance actions, operation effects, quality of parts, modifications, environment, and aircraft aging. The ongoing safety assessment process described in this document includes the following steps (see Figure 1):

- a. Hazard Identification
- b. Risk Assessment
- c. Risk Reduction/Mitigation
- d. Risk Control Implementation
- e. Hazard Tracking

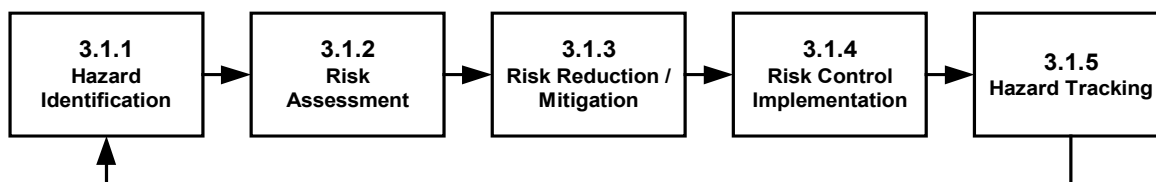


Figure 1 - Ongoing safety assessment process

3.1 Ongoing Safety Assessment Process

The ongoing safety assessment process is expected to be a continually improving closed-loop process. Figure 1 presents the ongoing safety assessment process. Each company defines the appropriate level of safety and the internal assessment approach within the company structure. This structure may vary from a complex structured formal organization to a very informal structure that simply recognizes a need for safety awareness. The company will determine the appropriate monitoring processes and procedures, and the definition of specific types of data to be collected and monitored. This may vary from a minimum of existing regulatory reportable issues to a more comprehensive set of undesired events. The exact parameters to be selected are the company's option based on the level of ongoing safety assessment process desired by management. The selection of specific parameters will be influenced by, among other things, the availability of data. Communication among the various levels of organizations is beneficial in establishing appropriate parameters. The ongoing safety assessment process includes the following steps.

3.1.1 Hazard Identification

Hazard identification encompasses collection of data and monitoring of the parameters. It also provides for recognition of events which have occurred and may be of concern, but were not previously identified. Sources of data are widely variable. Some typical examples are accident and incident investigation findings, service difficulty reports, warranty claims information, field service reports, and operator reports. Analysis of the data collected may be accomplished in a variety of ways to identify problems or trends. Some analysis techniques that may be used are identified in Section 4.

3.1.2 Risk Assessment

Risk assessment is the process that is initiated when an undesired event (or trend) is detected. Detection may be the result of internal or external data. Based on the significance of the event and initial evaluation of the risk, a more detailed and complete risk assessment is performed as appropriate. Assessment of risk may be accomplished using techniques such as those identified in Section 4. The assessment result is used to determine appropriate subsequent action. If further action is not required, the issue is documented and closed.

If the event warrants continued investigation, the organization needs to provide the potential event resolution. If the organization identifying the event has the capability and responsibility to pursue the corrective action, it does so, continuing through the process. In many cases, it will be appropriate that both internal and external actions are required. In the event both actions are required, the organization identifying the event may find it necessary to notify other responsible organizations while at the same time continue to pursue its own corrective action. When the responsible organization is contacted, they should use their own process. Those events that require airworthiness authority notification should be reported at this step.

3.1.3 Risk Reduction/Mitigation

Risk reduction/mitigation encompasses research into event causes and the development of corrective action(s). This should include risk assessment of potential corrective action(s).

3.1.4 Risk Control Implementation

Risk control implementation consists of evaluating the corrective action options and identifying those with acceptable levels of safety. This action is typically performed by a review board or management position, which approves the proposed corrective action, determines the implementation method (e.g., recommendation for mandatory actions by airworthiness authorities, alert service bulletin, service bulletin, engineering order, letter, etc.), and authorizes implementation by the responsible organization. If the recommended action is not approved, it can be reassessed for significance and possible refinement of the proposed corrective action. The approved corrective action is then reviewed for specific applicability and effects on others that are external to the organization. When applicability has been determined, the decision to implement the corrective action is made. If the decision is made not to implement, the decision is noted in the hazard tracking log and the action is closed. If the decision is made to implement, the corrective action is scheduled and tracked.

Implementation encompasses the action of placing the corrective action into effect which may involve aircraft design changes, modifications, maintenance actions, procedural changes, service bulletins, airworthiness directives, etc. When implementation is complete, the decision is made as to whether implementation involves external organizations. If implementation involves external organizations, they should be so notified.

3.1.5 Hazard Tracking

Hazard tracking is when the corrective action has been implemented (or not implemented, as appropriate) and the safety assessment process for that event is documented and closed. If the decision is not to implement the corrective action, the decision and its justification are documented and filed in the hazard tracking log. Lessons learned during the safety assessment process may be incorporated as appropriate.

As noted earlier, there are three basic organizational levels within the general aviation aircraft and rotorcraft community. The ongoing safety assessment process is similar for each of these three levels, but the size of the fleets for which they are responsible varies dramatically. This will cause the amount of safety effort and the level of detailed analyses to vary significantly. Table 1 shows the typical basic tasks of the ongoing safety assessment process for these three levels.

In some cases, the responsibility to conduct the hazard identification through the correction steps lies with another organization. Such “other organizations” should be notified of the potential hazard; they can use this same process and subsequently provide the correction activities and feedback to the originating organization. For example, an aircraft manufacturer may identify a potential hazard of a TSO part. The TSO vendor is notified, who then conducts his own risk assessment process and notifies the FAA and the aircraft manufacturer of the assessment status until the corrective action has occurred in the field. The TSO vendor would continue to monitor his TSO product.

3.2 Ongoing Safety Assessment Process Customization

Each user of this document is encouraged to develop its own ongoing safety assessment process and continuously adapt it to its specific operating needs and criteria. Most aviation companies already have a version or portions of this process. The information in this document may assist in development of a structured process, yet still include those existing functions. Communication with other operators, suppliers, manufacturers, and airworthiness authorities is advantageous throughout the process.

Table 1 - Ongoing safety assessment process summary

Steps (Paragraph)	Description
Hazard Identification (3.1.1)	Analyze monitored data to identify potential or real hazards. Potential sources: accidents/incidents, out-of-spec occurrences, etc.
	Typical sources: Computerized data, paper records, SDRs, etc. Some organizations may have only paper or limited records
	Use existing company functions and processes to provide inputs. (Customer support, quality, warranty, reliability, engineering, pilot reports, etc.)
	Non-company sources of failure/malfunction and accident/incident data on your product/services. (Worldwide accidents, NTSB, FAA, etc.)
Risk Assessment (3.1.2)	Assess severity and potential magnitude of fleet involvement.
Risk Reduction/Mitigation (3.1.3)	Identify root causes and extent of problem. Provide factual knowledge of potential hazard and assessment information to decision maker(s).
	If a potential hazard is deemed a safety issue, actions will be taken by company functions to fully understand the problem, initiate corrective actions, and make appropriate notifications (e.g., customers, suppliers, FAA, and other agencies).
Risk Control Implementation (3.1.4)	If potential hazard is not deemed a safety issue, document decision/rationale, and lessons learned.
	If potential hazard is deemed a safety issue, corrective actions should be applied to aircraft/component (e.g., alert service bulletins, service bulletins, or other documents to customers). Commercial operators should take appropriate internal actions.
	Notify FAA, other agencies if required.
Hazard Tracking (3.1.5)	Document problem and corrective actions in hazard tracking log. Apply individual lessons learned to avoid repeating a problem.

4. METHODS AND TOOLS

4.1 Risk Assessment Matrix

Analytical analysis techniques and tools are numerous and change through the years. A simple qualitative risk assessment matrix similar to Table 2 can be used to assess the relative effect of a potential hazard before and after mitigation. Such a matrix approach can provide a visual indication of the frequency and severity of different hazards. If detailed information is available, a more formal quantitative risk assessment can be done using the guidance of ARP5150 or other useful tools in Section 2. Similar risk matrixes are used in governmental Safety Management Systems (SMS).

A potential hazard can be assessed as to its severity (considering the aircraft and occupants, if it occurs) in the Hazard severity column. The likelihood of hazard occurrence is assessed in the hazard probability row. The risk assessment matrix intersection of the likelihood of the hazard probability occurring in the fielded fleet and the hazard severity is the relative risk assessment of that hazard before any mitigation activity occurs. Once the hazard reduction/mitigation has been identified, the resulting hazard is applied to the risk matrix again for the expected risk after mitigation. The risk mitigation should move toward less severity and less frequent. A user can customize this risk assessment matrix example to be consistent with his product or operation.

HAZARD PROBABILITY	HAZARD SEVERITY			
	CATASTROPHIC Fatal injury or aircraft severe damage or loss	CRITICAL Severe injury or substantial aircraft damage	MARGINAL Minor injury or minor damage	NEGLIGIBLE No significant effects
A. FREQUENT Continuously experienced.	Extremely High	Extremely High	High	Medium
B. PROBABLE Will occur frequently.	Extremely High	High	Medium	Low
C. OCCASIONAL Will occur several times.	High	High	Medium	Low
D. REMOTE Unlikely, but can be expected to occur.	Medium	Medium	Medium	Low
E. IMPROBABLE Extremely unlikely to occur, but possible.	Low	Low	Low	Low

Table 2 - Risk assessment matrix example

Table 2 provides an example of a risk assessment matrix. Representative definitions of severities and probabilities relative to risk assessment matrices can be found in Appendix C of FAA Order 8040.4B.

4.2 Hazard Tracking

Event tracking can be accomplished in many different ways. Issues arising from these events (hazards) can be tracked until that issue is closed. A sample airworthiness issue tracking form is shown in Appendix A to indicate the types of information desired. Users should develop their own form with information appropriate to their company.

4.3 Hazard Reporting

It is recommended that hazards be reported to the appropriate FAA standards branch, FAA certification office, or the OEM. This helps in identifying potential safety issues and the accuracy of risk assessments is improved.

5. RISK ASSESSMENT METHODOLOGIES

Risk assessment methodologies have been developed by the FAA that are available to use if desired by an organization. Different branches of the FAA have created risk assessment methods for different types of aircraft or systems. The rotorcraft and small airplane methods trace to a common process described in FAA AC 39-8. The transport airplane risk assessment uses a different data driven method. All methods comply with FAA Order 8110.107.

The following sections briefly describe each method and how to obtain a copy.

5.1 Rotorcraft Risk Analysis Handbook

The rotorcraft risk analysis handbook provides a data driven approach to estimate quantitative risk values associated with airworthiness concerns on a fleet of affected rotorcraft. The rotorcraft risk analysis handbook provides guidance as users evaluate the existence of an unsafe condition and make corrective action determinations. The methodology employs both fleet usage data and historical safety data (accidents, incidents, service difficulty reports, etc.) to calculate both short- and long-term risk values. Users compare calculated future risk values to the handbook's risk guidelines as defined by the following two severity levels:

- a. Level 5: Event results in a fatal accident.
- b. Level 4: Event results in either:
 - 1. Serious injury,
 - 2. Land immediately (as defined by respective flight manual), or
 - 3. Loss of aircraft control.

The FAA uses results of the quantitative risk analysis in conjunction with engineering judgement to determine whether airworthiness action should be taken. Lower severity levels are not considered for airworthiness action.

The two severity levels, their definitions, and the short- and long-term risk guidelines published in the rotorcraft risk analysis handbook were harmonized with the consensus reached during a series of benchmarking meetings from 2013 to 2014 between the rotorcraft industry and the FAA. The intent of the benchmarking was to implement standard quantitative risk guidelines for the rotorcraft industry. The benchmarking effort invited participation from all rotorcraft OEMs, engine manufacturers with products installed on rotorcraft, academia, and government agencies outside the FAA.

The handbook is publicly available upon request from the FAA's rotorcraft standards branch (aircraft certification service, policy, and innovation division), safety management section.

5.2 Small Airplane Risk Assessment

The small airplane risk analysis handbook (SARA) provides guidance for quantitative evaluation of the risk associated with potential continued operational safety issues within the small airplane fleet. If the SARA risk analysis reveals an unacceptable level of risk, SARA provides additional guidance for evaluating the effectiveness of proposed risk management control programs.

SARA is applicable to airplanes type certificated to Part 23 and predecessor regulations, airships, and gliders. SARA compares the risk at three safety hazard levels against risk guidelines to make recommendations on whether the FAA should consider taking continued operational safety actions. SARA considers:

- a. Level 5: An event that results in a fatal accident.
- b. Level 4: An event that results in serious injuries or large reductions in safety margins or functional capabilities of the crew.
- c. Level 3: An event that results in substantial damage to the aircraft or a reduction in safety margins or increased crew workload.

Lower severity levels are not considered for airworthiness action. SARA's risk guidelines consider the intent of the type certification regulations (e.g., certification class based on type and size), as well as the historic accident rate caused by specific groups of failures.

The SARA handbook is publicly available upon request from the FAA's small airplane standards branch (aircraft certification service, policy, and innovation division), continued operational safety section.

5.3 Transport Airplane Risk Assessment Method

The transport airplane risk assessment method (TARAM) handbook provides a data driven approach to estimate quantitative risk values associated with airworthiness concerns on a fleet of affected transport category airplanes. The TARAM handbook provides guidance as users evaluate a potential unsafe condition and make safety and corrective action determinations. The methodology employs both fleet usage data and historical safety data (accidents, incidents, etc.) to calculate both uncorrected and control program fleet risk and individual risk. Users compare calculated risk values to the handbook's risk guidelines to determine if an issue is unsafe; if so, then if the proposed control program is adequate.

The handbook (Policy PS-ANM-25-05) is publicly available from the FAA's regulatory and guidance library (RGL) in the policy database.

6. NOTES

6.1 Revision Indicator

A change bar (I) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.

PREPARED BY S-18 AIRCRAFT AND SYSTEMS DEVELOPMENT AND SAFETY ASSESSMENT COMMITTEE

APPENDIX A - SAMPLE OF AIRWORTHINESS ISSUE TRACKING FORM

The extent of tracking of airworthiness issues will vary by company. Tracking and the level of details needed should be customized and defined by the document user. In general, the following items could provide the basic information needed for tracking airworthiness issues.

Issue Number: (Unique identifier number for each model/component issue)

Issue Title: (One-liner general problem description)

Date: (Date that issue was identified)

Model: (Specific model or component identifier in question)

Condition/Extent Statement: (General statement of the potential problem with specific supporting details and extent that it affects the field, including specific serial numbers, if applicable)

Closing Action Summary: (A summary of the closing actions with rationale related to this issue including references of documents to the field and to regulatory authorities)

Issue Completed and Closed: (Date of closing)

Depending upon the user's organization and their desired level of tracking, additional items such as the following can be added if increased visibility is desired.

Supporting Information: (Includes information from previous similar issues/events, other sources, etc.)

System Code: (Functional/systematic coding such as ATA code to allow grouping of similar types of events or components)

Task 1 Assigned: (Brief title/description)

Task 1 Responsible Person: (Name of person who is assigned this task)

Task 1 Status: (Open or closed)

Task 1 Description: (Describe actions taken or not taken and the rationale)

Task 2 Assigned: (Repeat process as needed)

[End]